Appendix G Geographic Information System (GIS) Calculations

Using Geographic Information Systems (GIS), a preliminary optimization is performed outside and prior to the linear programming model to construct a supply curve for onshore wind, shallow offshore wind, and deep offshore wind for each region i and wind class c.

The pre-optimization minimizes:

$$\sum_{c,i,l,h,k} (GC_{c,l} + TC_{c,i,l,h,k}) \cdot W_{c,i,l,h,k} + \sum_{k} M \cdot D_k$$

Subject to:

$$\sum_{c,i,l,h,k} W_{c,i,l,h,k} + D_k \leq a_k \cdot T_k$$

where

$GC_{c,l}$ is the levelized cost of generation from a wind farm of type l at a class c wind resource site.

$TC_{c,i,l,h,k}$ is the levelized cost of building a transmission spur for class c wind of type l from grid square h in region i to transmission line k.

$W_{c,i,l,h,k}$ is class c wind of type l transported from grid square h in region i on transmission line k.

M is a large number (very high cost).

D_k is a dummy variable to ensure feasibility in the constraint below.

a_k is the fraction of the capacity (T_k) of line k available

Using the results of this pre-optimization, supply curves are constructed for each region i, for each type of wind resource l (onshore, shallow offshore, and deep offshore) and for each class of wind resource within that type. Each supply curve is made up of four wind resource/cost pairs identified by the subscript $wscp$ where $wscp$ takes on the values 1 through 4. The amount of wind resource in each step is set initially so that for each type of wind l:

$$WR2G_{c,i,l,wscp} = f_{wscp} \cdot \sum_{h,k} W_{c,i,l,h,k}$$

$$\text{where:} \quad f_i = 0.1 \cdot i$$

Thus, the first step on the supply curve is comprised of the 10% of all the class c wind grid squares in region i with the lowest cost to build transmission spurs to the grid. The next step consists of the 20% with the next lowest set of costs, etc. The cost, $WR2GPTS_{c,i,l,wscp}$, associated with each point or step on the supply curve is the mean levelized transmission spur cost for that step.

The supply curve quantity/price pairs—$WR2G_{c,i,l,wscp}$ and $WR2GPTS_{c,i,l,wscp}$—from this pre-LP optimization are input to the linear programming ReEDS model within the "Wind Supply Curve" constraints. In each period, the quantities, $WR2G_{c,i,l,wscp}$, are decremented by the amount of wind resource in that step deployed in previous periods.

Ideally, this preoptimization should be performed for each period of the ReEDS run with the costs of wind generation specific to that period (wind generation costs generally decrease from one period to the next either because of exogenously specified R&D-driven reductions in capital and operating costs, and/or because of learning through industrial experience). This is not possible because of time and computer resources required to conduct this optimization in GIS for the large number of wind grid squares considered. Currently, the optimization is conducted once using the wind cost/performance characteristics for the first period.